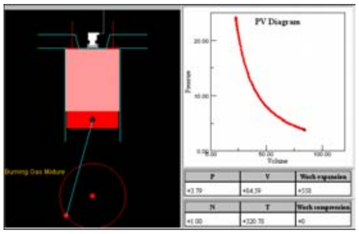
Worksheet for Exploration 21.2: Internal Combustion Engine



In this animation N = nR (i.e., k_B = 1). This, then, gives the ideal gas law as PV = NT. We will assume an ideal gas in the engine. Restart.

The Otto engine cycle is close to the cycle of an internal combustion engine (and closer to a real engine than the Carnot engine). This cycle consists of adiabatic and isochoric processes plus a cycle of exhausting smoke and taking in new gas. Identify which parts of the engine cycle correspond to which process. No net work is done in the complete process of exhausting smoke and taking in gas. Explain why. Notice that during this part of the cycle, the number of particles changes because the red valves at the top open and close to let gas in and out. Thus, in the release of high temperature particles and intake of low temperature particles, heat is exchanged (released to the environment).

a. For the adiabatic expansion, what are the initial pressure and volume? What are the final pressure and volume? (Remember you can click on the graph to read points from it.) From these values, find the adiabatic constant, γ (since PV^{γ} = constant for an adiabatic expansion).
   i. You will need to work out what γ must be.

P_i=________ V_i=________ $PV^{\gamma}{}_i$=________

P_i=________ V_i=________ $PV^{\gamma}{}_f$=________

b. Is the gas monatomic (γ = 1.67), diatomic (γ = 1.4), or polyatomic (γ = 1.33)?

γ=________

c. What is the net work done during the cycle (the work out)?

W_{net}=________

d. Neglecting the gas exhaust and intake parts of the cycle, in which part of the cycle is heat absorbed? In which part of the cycle is heat released?

e. Calculate the heat absorbed. Remember that $Q = \Delta U + W$ and that $\Delta U = f/2 N\Delta T$, where $f = 3$ for monatomic gases, 5 for diatomic gases and 6 for polyatomic gases.

f. What is the efficiency of this engine? The efficiency of an engine is: ε = (work out) / (heat in) = $|W| / |Q_H|$.

$$\varepsilon = (\text{work out}) / (\text{heat in}) = |W| / |Q_H| = \_\_\_\_\_\_\_\_$$

g. Check that your answer is equal to $1 - (V_{min}/V_{max})^{1-\gamma}$ and is therefore dependent on the ratio of the maximum and minimum volume (called the compression ratio).